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13. ABSTRACT *(Maximum 200 words)*
Our initial theoretical work with Dr. Yu. Godin on asymptotic models for 3D thin-film photonic crystals Is out. The results establish a possibility of spectral gaps and provide new computational tools for studies of 3D photonic crystals. A. Eigotin and Yu. Godin, "Spectral Properties of Thin-film Photonio Crystals", SIAN J. Appl. Math., 61, No. 6, pp. 2008-2035 (2001). We finished our work on nonlinear photonic crystals with quadratic nonlinearity including the role the group velocity matching for nonlinear interactions in periodic media. We can see looking at publications a growing interest to nonlinear periodic dielectric structures, especially with quadratic nonlinearity. We believe that the work we have conducted is an achievement in that area. We learned from the editor that our paper was "one of the most accessed orticles for the Journal last year". A. Eabine and A. Figotin "Nonlinear Photonic Crystals. I. Quadratic Nonlinearity", Waves in Random Media, II, pp. R3l-R102 (2001) The work on the development of computationally efficient "Resolvent method" for localized states in 2D photonic crystals of the square geometry is completed. We believe that the proposed method is superior in both the speed and the accuracy of computation. A. Figotin and V. Curen, "Resolvent Method for Computation of Localized Defect, Modes of H-polarization in 20 Photonic crystals, Phys. Rev. E, 64, 056623, 2001. Rev. E, Vol. 63, pp. 066609-1 -066609-17, 2001. All the computational work was carried out en our 581 ''Octane'' computers as well as 32 CPU parallel 581' 'Origin 2000'' computer.

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To:	Nachman, Arje
Cc:	Nancy Kelly; Soo Lee; jbermude@uci.edu
Subject:	Final Report, 2002, for Contract No. F49620-99-1-0203.

Dear Arje,

Please find below my Final report for Contract No. F49620-99-1-0203.

Please confirm the receipt of the message.

Thank you, Alex Figotin.

Final Report, 2002, for Contract No. F49620-99-1-0203.

1. Title: ''Tunable Photonic Crystals''.

2. AFOSR Contract No. F49620-99-1-0203.

3. Finral Report for the period October 1, 1999 - May 31, 2002.

4. PI Name: Alexander Figotin, Department of Mathematics, University of
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I. OBJECTIVES.

1. Develop time efficient and reliable methods for the computation of
the band gap structures for 2D photonic crystals of the general geometry
and 3D photonic crystals with cubic geometry. Develop asymptotic theory of
3D thin-film photonic crystals.

2. Develop the theory of nonlinear interactions in 1D, 2D and 3D
photonic crystals.

3. Develop the methods for the computations of the localized eigenmodes
and their frequencies generated by the defects in photonic crystals.

4. Develop the theory on magnetic photonic crystals. Applications
of magnetic photonic crystals.

5. Explore the applications of magnetic photonic crystals in
submillimeter range of frequencies.

II. STATUS OF EFFORT

1. Our initial theoretical work with Dr. Yu. Godin on asymptotic models
for 3D thin-film photonic crystals is out. The results establish a
possibility of spectral gaps and provide new computational tools for
studies of 3D
photonic crystals.

 A. Figotin and Yu. Godin, "Spectral Properties of Thin-film Photonic

1

Crystals", SIAM J. Appl. Math., 61, No. 6, pp. 2008-2035 (2001).

2. We finished our work on nonlinear photonic crystals with quadratic
nonlinearity including the role the group velocity matching for
nonlinear interactions in periodic media. We can see looking at
publications a growing interest to nonlinear periodic dielectric
structures, especially
with quadratic nonlinearity. We believe that the work we have conducted
is an achievement in that area. We learned from the editor that our
paper was "one of the most accessed articles for the Journal last year".

A. Babine and A. Figotin "Nonlinear Photonic Crystals. I. Quadratic
Nonlinearity", Waves in Random Media, 11, pp. R31-R102 (2001).

3. The work on the development of computationally efficient "Resolvent
method" for localized states in 2D photonic crystals of the square
geometry is
completed. We believe that the proposed method is superior in both the
speed and
the accuracy of computation.

A. Figotin and V. Goren, "Resolvent Method for Computation of
Localized Defect, Modes of H-polarization in 2D Photonic crystals,
Phys. Rev. E, 64, 056623, 2001.

4. Our theoretical results on magnetic photonic crystals have been
completed and published. The results can have important applications for
more
efficient and of smaller dimensions antennas.

A. Figotin and I. Vitebskiy, "Spectra of Periodic Nonreciprocal
Electric Circuits", SIAM J. Appl. Math., 61, No. 6, pp. 1959-1979 (2001).

A. Figotin and I. Vitebskiy, "Nonreciproal Photonic Magnetic Crystals",

Phys. Rev. E, Vol. 63, pp. 066609-1 -066609-17, 2001

6. All the computational work was carried out on our SGI
''Octane'' computers as well as 32 CPU parallel SGI''Origin 2000''
computer.

Dr. Godin and Dr. Goren have written the codes for the parallel
computer and use of the parallel computer became routine.

III. ACCOMPLISHMENTS/NEW FINDINGS.

1. Our work with Dr. Vitebskiy on nonreciprocal (gyrotropic)
photonic crystals has shown that one can achieve strong
nonreciprocity just by proper arrangements of common and
widely available dielectric materials.

Here are the main attractive features of microwave, millimeter, and
submillimeter devices utilizing our invention:
- substantially smaller weight and dimensions
- multifold enhancement in power capabilities
- tunability
- excellent survivability
- functionality under harsh external conditions including:
temperature, impacts and blows, vibrations, any radiation
- versatility

The theory of those structures are described in
our Phys. Rev. E paper with Dr. Vitebskiy.

2. Our work with Dr. Babine on the nonlinear photonic crystals
provides solid theoretical base for the studies of a number
on nonlinear regimes in periodic dielectric structures. Based
on the Stationary Phase Method applied to oscillatory interaction
integrals arising in nonlinear Maxwell equations, we described
all important selection rules of stronger nonlinear interactions,
and developed a quantitative classification of nonlinear interactions.

In particular, we have shown the for regimes under study
the group velocity matching, not the frequency matching
(as commonly believed), is the most important selection rule.

IV. FACULTY SUPPORTED:

Dr. A. Babine, Dr. Yu. Godin, Dr. V. Goren and Dr. I. Vitebskiy.

V. PUBLICATIONS and SUBMITTED PAPERS for the
reported period:

(1) A. Figotin and Yu. Godin, "Spectral Properties of Thin-film Photonic
Crystals", SIAM J. Appl. Math., 61, No. 6, pp. 2008-2035 (2001).

(2) A. Figotin, Yu. Godin, I. Vitebsky, "Tunable Photonic Crystals"
in ''Material Research Society Symposium Proceedings'', Vol. 603,
1999 Material Research Society, KK6.1.1-KK6.1.6. (We learned
that the paper is out in the reported period).

(3) A. Babine and A. Figotin "Nonlinear Photonic Crystals. I. Quadratic
Nonlinearity", Waves in Random Media, 11, pp. R31-R102 (2001).

(4) A. Figotin and V. Goren, "Resolvent Method for Computation of
Localized Defect, Modes of H-polarization in 2D Photonic crystals,
Phys. Rev. E, 64, 056623, 2001.

(6) A. Figotin and I. Vitebskiy, "Spectra of Periodic Nonreciprocal
Electric Circuits", SIAM J. Appl. Math., 61, No. 6, pp. 1959-1979 (2001).

(7) A. Figotin and I. Vitebskiy, "Nonreciproal Photonic Magnetic
Crystals", Phys. Rev. E, Vol. 63, pp. 066609-1 -066609-17, 2001.

VI. CONFERENCES and INVITED TALKS:

A. Figotin, "Spectral Theory and Oscillatory Integrals in Nonlinear
Interactions", International Workshop on Mathematical Physics,
Brazil, Mambucaba, August 19 - 25, 2001

I. Vitebskiy, "Gyrotropic Photonic Crystals",
Condensed Matter Theory Seminar, UCI, May 2001.

A. Figotin, "Nonlinear Wave Interactions in Periodic Media",
AMS conference, Los Vegas, April 21-22, 2001

A. Figotin, "Three-dimensional Thin-Film Photonic Crystals",
Electromagnetics Workshop, Brooks Air Force Base, San Antonio,
January 2000

A. Figotin, "Spectral Theory in Nonlinear Wave Interactions",
AMS conference, Birmingham, Alabama; November 10-12, 2000

A. Babine, "Nonlinear Phenomena in Periodic Dielectric Media",
2000 AFOSR Workshop on Nonlinear Optics, Tucson, September 2000.

International Workshop "Quantum Spectra and Dynamics", Israel,
"Nonlinear phenomena in periodic dielectric media", July 2000,
A. Figotin.

Weizmann Institute, Rehovot, Israel,
"Nonlinear phenomena in periodic dielectric media", July 2000,
A. Figotin.

Electromagnetics Workshop, Brooks Air Force Base, San Antonio,
"Wave Propagation in Weakly Nonlinear Periodic Media", January 2000,
A. Figotin

"Material Research Society Symposium, "Photonic Crystals", November,
1999,
A. Figotin & I. Vitebskiy

The Second International ISAAK 99 Congress, Japan ,
"Spectral Theory in Weakly Nonlinear Periodic Media", August, 1999,
A. Figotin

Air Force Institute of Technology, Wright-Petterson Air Force Base,
Dayton, Ohio, "Wave Propagation in Weakly Nonlinear Periodic Media",
July, 1999, A. Figotin

International AMS Summer Research Conference
''Wave Phenomena in Complex Media'',
"Spectral Theory in Weakly Nonlinear Periodic Media", June, 1999, A.
Figotin.

Department of Mathematics, Southern Methodist University, Dallas, TX.
Mathematical modeling of photonic crystals.
September 20, 2000, Yu. Godin.

Steklov Institute of Mathematics at St.Petersburg, Russia.
Spectral properties of thin-film photonic crystals.
July 28, 2000, Yu. Godin.

Corning Scientific Center in St.Petersburg, Russia.
Tunable photonic crystals.
July 21, 2000, Yu. Godin.

Physico-Technical Ioffe Institute, St.Petersburg, Russia.
An asymptotic model of three-dimensional photonic crystal.
July 20, 2000, Yu. Godin.

WAVES 2000: 5-th International Conference on Mathematical and Numerical
Aspects of Wave Propagation.Santiago de Compostela, Spain.
Asymptotic model of Three-Dimensional Photonic Crystal.
July 10--14, 2000, Yu. Godin.

Facultad de Ciencias, Universidad Autonoma de Madrid, Spain.
Theory of spectra of thin-film photonic crystals.
July 6, 2000, Yu. Godin.

Fisica I Enginyeria Nuclear, Universitat Politecnica de Catalunya,
Spain.
Theory of spectra of thin-film photonic crystals.
July 3, 2000, Yu. Godin.

The Second Irvine Days in Applied and Computational Mathematics,

Calculation of the spectrum of some two- and three-dimensional photonic
crystals.
May 14, 2000, Yu. Godin.

Nuclear Research Center Soreq, Israel.
Calculation of the spectrum of some two-dimensional photonic crystals.
July 14, 1999, Yu. Godin.

Physics Department, Van der Waals-Zeeman Institute, University of
Amsterdam, Netherlands.
Calculation of the spectrum of some two-dimensional photonic crystals.
July 9, 1999, Yu. Godin.

Seminaire de Physique mathematique et Geometrie, Universite Paris 7,
France.
Calculation of the spectrum of some two-dimensional photonic crystals.
July 7, 1999, Yu. Godin.

Department of Physics, University of Bath, United Kingdom.
Calculation of the bandgap structure of some two-dimensional photonic
crystals.
July 1, 1999, Yu. Godin.

Department of Mathematics, University of Liverpool, United Kingdom.
Calculation of the spectrum of some two-dimensional photonic crystals.
June 29, 1999, Yu. Godin.

VII. Patents.

We filed the provisional patent application
UC Case No. 2001-350-1

"Gyrotropic Photonic Crystal and Applications for the Same"
acknowledging the support of AFOSR.

The patent is related to our recent results on magnetic photonic
crystals.

VII. INTERACTIONS/TRANSITIONS.

Our work on nonreciprocal and magnetic photonic crystals
received an attention from the industry.

We established working relations with Dr. D. Barker from Raytheon,
and arranged a meeting with a group of Dr. G. Schultz from Boeing.

We had a meeting with a group of representatives from Raytheon
in January 2001 in UCI, Office of Technology Alliances.
The subject of the meeting was potential applications of nonreciprocal
(gyrotropic) photonic crystals to microwave devices with enhanced
performance and of smaller dimensions. It is my impression that
Dr. Barker and Raytheon's attorney recognized a significant potential
of proposed by us new dielectric structures. UCI provided all necessary
documents to establish research partnership with Raytheon.

A similar meeting took place with representatives of Boeing,
including Dr. G. Schultz, in Boeing West Hills Laser & Electro Optical
Systems.

Dr. Schultz indicated an interest not only to applications of our work
to devices of
traditional frequencies but also to optical frequency range. This
indicates that what used to be just a theoretical possibility

may be today practical enough for utilization in useful devices.